

2004

RAMP METERING

ANNUAL REPORT

District 07
Los Angeles and Ventura Counties



STATE OF CALIFORNIA
Governor Arnold Schwarznegger

BUSINESS, TRANSPORTATION AND HOUSING AGENCY
Secretary Sunne Wright McPeak

DEPARTMENT OF TRANSPORTATION
Director Will Kempton

DIVISION OF OPERATIONS
OFFICE OF FREEWAY OPERATIONS
Ramp Metering Branch



December 2005



2004 RAMP METERING ANNUAL REPORT

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DEPARTMENT OF TRANSPORTATION

DISTRICT 07

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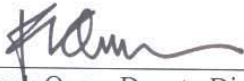
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RAMP METERING ANNUAL REPORT

District 07

This 2004 RAMP METERING ANNUAL REPORT, for District 07, has been prepared under the direction of the following registered engineer. The registered Civil Engineer attests to the technical information contained therein and has judged the qualifications of any technical specialists providing engineering data upon which recommendations, conclusions and decisions are based.

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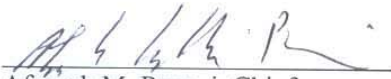
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ACKNOWLEDGEMENTS

RAMP METERING ANNUAL REPORT is prepared by the Office of Freeway Operations, Ramp Metering Branch in District 07. The information in this report encompasses all ramp and connector meters in Los Angeles and Ventura Counties.

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Special thanks to:

Chester Otani for his ideas, providing references and helps in writing this manual.

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EXECUTIVE SUMMARY

This is the first Ramp Metering Annual Report for Caltrans District 07, which covers Los Angeles and Ventura Counties. The purpose of this report is to document all accomplishments by the Ramp Metering Branch during the course of 2004, and acknowledge the foundation work done in 2002 and 2003.

Caltrans is committed to using ramp metering as an effective traffic management strategy to maintain an efficient freeway system and protect the investment made in constructing freeways by keeping them operating at or near capacity. Ramp Metering is an integral part of the system management concept, which focuses first on implementing operational strategies to reduce congestion and increase safety on California's State highway system.

Advanced Transportation Management System (ATMS), located in the Traffic Management Center (TMC) has been an important tool for the ramp metering operation. ATMS provides historical and real-time data of traffic volumes and occupancies for on-ramps and freeway mainlines. This data constitutes a vital and often primary source in determining the appropriate metering rates unique to each ramp meter location. In addition, ramp metering engineers using the ATMS display map for District 07, can modify ramp meter parameters and time of operation. This feature is often used when responding to major traffic incidents or lane closures due unforeseen events or scheduled construction projects. Thus, the use of ATMS in district 07 leads to an increase in efficiency, by allowing faster response to dynamic field situations.

System wide Adaptive Ramp Metering (SWARM) has been implemented on various sections of the freeway system, in the past four years. It holds the promise to improve metering efficiency throughout the entire freeway system. However, SWARM testing and implementation require multiple resources and numerous manpower and financial allocations, which were scarce for the past few years. However, It is anticipated that reasonable amount of resources will be available in the coming years, in order to implement SWARM district wide and capture the benefits generated by this new technology.

DISTRICT 07 RAMP METERING HISTORY

In 1965, the Freeway Operations Department was created in District 07 to locate, analyze and solve operational problems on the existing freeway system.

The first experimentation with ramp metering in District 07 occurred on a Labor Day weekend in the mid 1960's on the S/B Route 14 connector to the S/B Route 5 Freeway. The S/B Route 14 connector was manually metered with temporary signals, thus preventing the S/B Route 5 Freeway from breaking down. The metering operation was a complete success.

On April 11, 1967, the District's first two permanent fixed time ramp meters were installed on the northbound Hollywood Freeway (Route 101) at Sunset and Hollywood Boulevards. The project was successful in relieving congestion on the freeway without seriously affecting surface streets operation. Freeway delay was reduced by 75%.

In the early 1970's, District 07 created the Los Angeles Area Freeway Surveillance and Control Project (LAAFSCP). This experimental project, known as the 42-mile loop, was located on the Harbor Freeway (Route 110), Santa Monica Freeway (Route 10) and the San Diego Freeway (Route 405). The two primary objectives of the system were: first to test and evaluate various techniques for improving movement of people and goods on the freeway by reducing delay, accidents and motorists' frustration and second to integrate those techniques showing a great promise into an effective traffic management system.

The LAAFSCP project consisted of a vast network of traffic sensors, telemetry equipments, in addition to a computer system for traffic data processing. The system provided real-time traffic data, a map display and an operator's console. This was the beginning of the current Transportation Management Center (TMC).

The LAAFSCP project provided traffic engineers with data on a 24-hour basis, including mainline volumes, speeds, occupancies and ramp volumes. Additional information provided by the system included travel time and delay.

Traffic responsive ramp metering was tested in the LAAFSCP project. The traffic responsive logic showed a great improvement over the existing fixed time traffic controllers.

Also in the early 1970's, District 07 developed "A Program to Upgrade and Control the Los Angeles Freeway Network". This program looked at sections of freeways that needed to be widened due to very heavy traffic demands. It was noted that as projects were completed, freeway congestion disappeared. However, as time went on, congestion returned since many motorists that were formerly taking City streets discovered the faster moving freeways. Ramp meters were then installed to control the input onto the freeway system and to keep motorists on City streets, especially the local ones.

In 1992, the first connector meter in District 07 was installed on the S/B Route 5 connector to the S/B Route 110 Freeway. In 1993, Route 105 (Glenn Anderson Freeway) was opened to traffic. Design and Construction of the 105 freeway included a large number of connector meters. Implementation of connector metering was possible on Route 105, due to long and wide connectors providing adequate storage and sufficient sight distance for fast approaching vehicles, especially on heavy volume connectors. There are total of 19 connector meters in District 07, 17 are currently operating.

Today, ramp metering represents one important element of the Traffic Management System (TMS). The focal point of TMS is maximizing traffic flow on the freeway system by reducing congestion. Other elements of TMS include:

- Freeway Surveillance Equipments – provides essential traffic data to the TMC for early detection of incidents and locates areas of traffic congestion. Freeway surveillance equipments are part of the ramp meter detection system and are installed and maintained by Ramp Metering Branch, ITS Branch and Electrical Maintenance Branch.
- Closed Circuit Television (CCTV) – Cameras with zoom capabilities are used to confirm the exact location, nature and severity of freeway incidents.
- Changeable message signs (CMS) – The TMC manages numerous signs located at key points on the freeway system. The TMC updates the display of CMS messages to provide real time traffic information to motorists.
- Highway Advisory Radio (HAR) – A short-range broadcast radio with transmitters located within the freeway right-of-way to provide motorists with updated informational messages such as directional advisories, traffic control restrictions as well as general information. HAR messages are remotely activated from the TMC.
- Freeway Service Patrol (FSP) – It is a fleet of tow trucks that patrol fixed travel routes continuously during the rush traffic hours providing early detection and rapid removal of minor incidents.

RAMP METERING BASICS

Ramp meters are traffic signals placed on freeway entrance ramps or freeway connectors to control the flow of vehicles entering the freeway or moving from one freeway to another. They are designed to decrease congestion and improve the average speed of vehicles traveling on the freeway, by controlling vehicular flow at most inputs onto the mainline. By installing a traffic signal at the on-ramp, Caltrans can control the rate at which vehicles enter the freeway. Vehicles entering at short intervals are less likely to slow down flowing traffic and can merge onto the freeway without causing the traditional

bottlenecks, associated with heavy on-ramp traffic volumes. In addition, metering has been proven to reduce rear end and sideswipe traffic collisions, especially during congestion periods.

The capacity of a freeway, in a free flow condition, can easily exceed 2000 vehicles per hour per lane (vph/l). However, during congestion periods, this number often drops below 1500 vph/l. Thus, a free-flowing traffic lane can carry 33% more cars than a congested lane. It is in the public interest to keep the freeways moving at free flow condition. Therefore, by breaking up vehicular platoon onto the mainline, ramp metering help to increase the total number of vehicles travelling on the freeway.

At some locations, where metered on-ramps include a high occupancy vehicle (HOV) bypass lane, vehicles with two or more occupants, using these lanes, get priority access to the mainline. This promotes carpooling while reducing the overall number of vehicles on the freeway.

Additionally, ramp meters are used to discourage short distance travelers from using the freeway. During congestion periods, many City streets paralleling the freeways are underutilized. Thus, motorists using local arteries, to avoid the wait at the ramp meter, will realize that it might be faster to use City streets, especially for short distance trips, than opting for the freeway. As a result mainline traffic flow and speed will improve, due to less vehicles entering or travelling on the freeway.

The following documents were prepared by Caltrans to guide in implementing ramp metering policy throughout the State:

Caltrans policy on Ramp Metering is defined in Deputy Directive DD-35. See ATTACHMENT 1.

RAMP METERING POLICY PROCEDURES, dated August 1997, provides guidelines for implementing the Department's Ramp Metering Policy (DD-35). See ATTACHMENT 2.

Design of ramp metering facilities is governed by "Ramp Meter Design Guidelines". Refer to REFERENCES, Item No. 1.

BENEFITS OF RAMP METERING

The effectiveness of ramp meter systems has always been questionable. It is difficult to quantify ramp metering benefits, without conducting a detailed study to compare with and without effects of ramp metering implementation.

In 2000, Minnesota Legislature passed a bill that required The Minnesota Department of Transportation (MnDOT) to study ramp metering effects in their State. Thus, MnDOT,

responsible for managing freeway access in the Twin Cities (Minneapolis and St. Paul) metropolitan area, conducted a four month study aimed towards capturing these benefits. Data was collected during two different time periods; ramp meters were turned on in the first period then turned off in the second. After analyzing the data from both periods, it was concluded that ramp metering is a cost-effective investment. In addition, the study revealed the following ramp metering benefits:

- 21% reduction in accidents
- 8% increase in speed
- 22% reduction in travel time
- 16.3% increase in throughput capacity

For detailed information, please refer to REFERENCES, Item No. 11.

TYPES OF RAMP METERING

There are three types of ramp meter operation in District 07:

1. Fixed time/Time of Day
2. Local Traffic Responsive
3. System Wide Adaptive (SWARM)

It should be noted that all three types of metering operation could be implemented according to the following two modes:

- One Car per Green Metering -- One vehicle per cycle per lane is permitted to enter the freeway. Assuming that green time is typically 2 seconds, the remaining cycle is red time varying from 2 to 18 seconds. In District 07, typical metering cycle (Red + Green) time does not exceed 12 seconds or 300 vehicles per hour per lane (vph/l), in order to minimize meter violations and reduce vehicle back up onto local City streets.
- Platoon Metering -- Two to three vehicles per cycle per lane are permitted. Typically, platoon metering is used at freeway connectors or heavy ramps, where traffic volumes exceed 900 vph/l.

1. Fixed Time/Time of Day

Fixed time ramp metering is the simplest form of ramp metering which breaks up platoons of vehicles entering the freeway. The ramp meter is programmed to operate based on a single or multiple fixed metering rates, for a preset metering period, based on historically averaged traffic conditions. Thus, the cycle length is “set” and does not change or respond to freeway mainline conditions. This is the primary drawback of this metering system. In addition, if the on-ramp gets congested, vehicle backup (Queue) reaches near City street, the Queue loop, usually located at the entrance of the ramp, will

be triggered and the meter rate will increase to maximum rate (15 vehicles/minute/lane) until traffic back up at the ramp is relieved. Metering rates can vary from 180 to 900 vph/l and 600 to 1320 vph/l for platoon metering. This type of ramp metering is used on a limited basis in District 07 when mainline loops are down or during construction.

2. Local Mainline Traffic Responsive Metering

In addition to all the features of fixed time metering, local mainline traffic-responsive metering is directly influenced by local mainline just upstream of the ramp and ramp traffic conditions, during the metering period. If the volume and the occupancy on the mainline freeway drop below a set critical volume and critical occupancy, the controller can override the set metered rates and allow more cars on the freeway up to the point of turning the meters to constant green light. The primary criticism of local mainline responsive operation is that it reacts only to traffic conditions adjacent to the ramp and does not consider what is happening throughout the rest of the freeway system. Traffic responsive metering is widely used in District 07.

3. System Wide Adaptive Ramp Metering (SWARM)

As the name indicates, it adapts the local traffic responsive concept to a whole section of freeway. For additional information, please refer to “SYSTEM WIDE ADAPTIVE RAMP METERING” section of this report.

RAMP METERING TECHNOLOGY

ADVANCED TRANSPORTATION MANAGEMENT SYSTEM (ATMS)

The Advanced Transportation Management System (ATMS) was designed to assist in collection and dissemination of traffic information, in order to effectively manage the existing District 07 Transportation System. Refer to REFERENCES, Items No. 6, 7, and 14. The activities in the Traffic Management Center (TMC) is intended to reduce congestion and increase safety through the rapid detection of, response to, and removal of incidents on the freeway. Ramp Metering engineers using ATMS workstations, located in the TMC, can manage recurring congestion by remotely controlling ramp meter operation and analyzing freeway system efficiency, through historical report data.

Additional ATMS enhanced features include incident detection, closed circuit television (CCTV) cameras to view traffic conditions, use of changeable message signs (CMS) and highway advisory radio (HAR).

Ramp metering field hardware is the key element in providing data to the ATMS. The loop detector system on the freeway mainline, on-ramps, off-ramps, connectors, etc., is all tied to traffic controllers that send data to the ATMS. Ramp Metering, ITS and

Electrical Maintenance personnel are responsible for new installations, upgrading or modifying existing installations as well as maintaining all existing field elements.

SYSTEM WIDE ADAPTIVE RAMP METERING (SWARM)

System Wide Adaptive Ramp Metering, also known as SWARM, is a relatively new ramp meter operating system developed by National Engineering Technology (NET) Corporation, based on District 07, ramp metering unit inputs and recommendations.

SWARM seeks to optimize traffic flow on the mainline by being responsive to actual conditions, throughout the system and to recurrent and non-recurrent congestion.

Types of SWARM

There are three basic types of SWARM: SWARM 1 operates system wide to predict congestion, SWARM 2a and SWARM 2b operate locally and are based on headway and storage respectively.

SWARM 1

SWARM 1 is system wide adaptive and based on a freeway network divided into SWARM sections. Each section begins and ends at a mainline vehicle detection station (VDS) identified as a bottleneck. SWARM 1 algorithm operates at designated bottleneck locations and controls vehicle flow of all upstream on-ramp locations linked to that bottleneck.

Since density is directly related to congestion, it is monitored at each bottleneck location. The algorithm requires a nominal saturation density threshold for each mainline VDS in the network.

The algorithm attempts to estimate the density n minutes (user settable) in the future. When estimated density, at the bottleneck, exceeds saturation density, ramp meter rates will be computed in an attempt to proactively react to the predicted onset of congestion.

Starting at the bottleneck and working upstream, the computer calculates new metering rates based on the required volume reductions. Actual metering rates vary between maximum and minimum rate. Since rate adjustments may be positive or negative, excess or reduction values are propagated upstream.

SWARM 2a

SWARM 2a is local responsive based on headway (time between consecutive vehicles). It uses density function to compute local metering rates and attempts to maintain headway such that maximum flow can be obtained.

SWARM 2b

SWARM 2b is local responsive based on storage. It computes the number of vehicles stored between two VDS stations and compares it to a maximum storage value. Metering rates are computed to maintain level of service (LOS) D as long as possible.

Combinations of SWARM

SWARM can be used in combinations, i.e., SWARM 1 and 2b can be combined. The controller uses the more restrictive rates of those recommended. Within a bottleneck segment, some controllers can be placed on local Time of Day mode, while others are placed in one of the SWARM modes. The use of the local Time of Day mode is especially useful at on-ramps that experience heavy back up and can not further restricted.

Advantages of SWARM

- It maximizes traffic flow on the mainline.
- It is responsive to actual traffic conditions throughout the system.
- It is responsive to recurring and non-recurring congestion.

Disadvantages of SWARM

- Ramp control and traffic surveillance devices must be connected to a computerized communications center.
- Communication lines have to be maintained at all times in order for SWARM to operate properly.
- SWARM requires accurate data from mainline and on and off-ramp detectors in order to work effectively.
- It is more complicated than traffic local traffic responsive metering.

SWARM Testing

SWARM was tested in 2001 and 2002, on routes 210 and 405. Results of route 210 study were published in the “PRELIMINARY SWARM STUDY REPORT” dated November 2001 and the “SWARM STUDY FINAL REPORT” dated October 2002. A brief summary was prepared following route 405 study in 2002. Please refer to REFERENCES, Item Nos. 4, 5 and 16. Currently, there are plans to test and possibly implement Swarm on routes 605, 118 and 105.

SATMS 3.0

SATMS is an acronym for Semi-Automatic Traffic Management System. SATMS 3.0 is a new computer processor chip developed recently by Caltrans ITS to upgrade the existing chips. The previous versions were SATMS 1, used only at on-ramps and SATMS C for both connector and on-ramp locations.

The primary goal for the SATMS chip upgrade is to make it compatible with the new ramp metering algorithm, known as SWARM. However other features were also added to the new chip in order to enhance the overall ramp meter operation.

In 2002, SATMS 3.0 chip was tested at several locations district wide. Once the testing phase was completed, the updated chip was installed at all on-ramp controller cabinets (except at Route 105 connectors). By the end of 2003, ramp meter operation was universal district wide as SATMS 3.0 chip replaced all previously existing ones.

The new features in the SATMS 3.0 chip are:

- Speed up the controller 170 initiation reset time following a power failure, which reduces the watchdog black out problem. Therefore, variation or brief interruption in power voltage level will have less effect on the operation of the ramp meter.
- The loss of communication Cycle Time is increased from one cycle (approximately 30 seconds) to ten cycles or around five minutes, in order to minimize frequent changes between Swarm and local Time of Day (TOD) modes. Thus, communication losses lasting no more than ten cycles would not affect the implementation of Swarm in the field; the controller would meter for up to five minutes, according to the last Swarm rate before communication failure occurred.
- Queue override maximum rate can be set by the Engineer to be lower than 15 vehicles per lane per minute. In addition the new chip provides the ability of linking the activation of the Queue override mode to mainline traffic condition by setting a threshold speed level to control Queue activation.
- Queue Override mode created to speed up the metering rate when vehicular back up reaches the entrance of the on-ramp can be used with Swarm mode. If activated, the

Queue override mode, in case of a ramp back up, will gradually increase the metering rate dictated by Swarm up to a maximum rate of 15 vehicles per lane per minute; Therefore, reducing the overflow of vehicles onto city streets.

- Whenever metering is initiated or terminated by Swarm or loss of communication cycle time exceeds ten cycles, the controller will apply one minute Green light at the beginning and end of each metering phase.
- Set improved default values for the SATMS 3.0 chip over the previous ones.
- Improve the program's traffic responsive feature.
- For Connectors only: Q2 loop operation is enhanced as follow:
 1. Q2 can be programmed to operate independently of Q1 to trigger green light, when backup occurs.
 2. Similarly to on-ramps Queue 1 Override maximum rate can be set at lower than 15 vehicles per lane per minute. In addition, Queue 1 and 2 activation modes can be controlled by mainline threshold speed level set by the engineer.

ITS (Intelligent Transportation System) BRANCH AND ELECTRICAL MAINTENANCE BRANCH

Both Electrical Maintenance and ITS Branch work as a team with the Ramp Metering unit. Thus, ramp metering engineers, in charge of the operation of ramp meters District wide, report all trouble issues to both Electrical Maintenance and ITS Branch, for prompt repairs. In addition, as a way to exchange ideas and resolve any outstanding issues related to the repair and improvement of the ramp metering system, these three groups meet quarterly.

The ramp metering system in the District is regularly inspected and observed through routine field surveillance and frequent ATMS observation. Ramp metering engineers are responsible for the ramp meter programmed software as well as the proper operation of all field hardware. Ramp meter operation software consists of a Ram Map package which includes a program sheet, Time of Day (TOD) table and a detailed loop detector (sensor) diagram layout, in addition to an electrical as-built plan showing traffic loops and underground hardware locations. Ramp meter hardware includes signals, controllers, loop detectors, signing, striping and advance warning devices. Area Engineers (lead workers) are assigned ramp meters by routes or segments of routes. Other engineers within the Ramp Metering Branch assist the Area Engineers. For more details, please refer to ATTACHMENT 3.

ELECTRICAL MAINTENANCE

Electrical Maintenance responds to ramp meter malfunctions reported by CHP, Ramp Metering Branch, ITS Branch and the general public, if related to hardware and electrical problems. As a routine procedure, Electrical Maintenance performs a 120-day check up (60 day check up prior to 2004) of all ramp metering equipments. The following main actions are performed by the Electrical Maintenance technician during this check up:

- 1- Inspect any damage or irregularity to field hardware.
- 2- Test proper operation of the Meter signal and the “Meter On” Sign.
- 3- Inspect flashing beacons for proper operation.
- 4- Inspect and maintain pull box covers (broken, missing, covered with debris).
- 5- Visual check of service cabinets and equipment locks.
- 6- Visual check of the roadway loops if possible.
- 7- Visual check and test of all the equipment inside the cabinet.

ITS BRANCH

ITS Branch provides technical support for the Transportation Management Center (TMC). This includes ramp metering and ATMS. ITS main duties are:

- 1- Test and develop new software related to metering operation.
- 2- Set up the configuration of ATMS.
- 3- Review electrical design plans for new projects.
- 4- Monitor and correct any discrepancies found on the ATMS data reports such as icons, loop configuration, etc.
- 5- Check system electrical operation and final compliance in accordance to the contract documents or as builds on all new and replacement equipment
- 6- Test and maintain communication lines between field equipments and TMC.

RAMP METERING BRANCH PRODUCTION

Ramp metering branch production was divided into work categories as follows:

1. Surveillance and Monitoring of ramp meters' operation.
2. Ramp Meter Counts
3. Capital Project Review
4. IGR / Permit Project Review
5. Metered Ramp Data Summary
6. Ramp Meter Development Plan
7. Ramp Metering Field Procedure Manual

The following sections summarize in depth the amount of work performed for each of these categories. All data included in the sections below was obtained from Weekly Ramp Meter Reports filed by all lead workers.

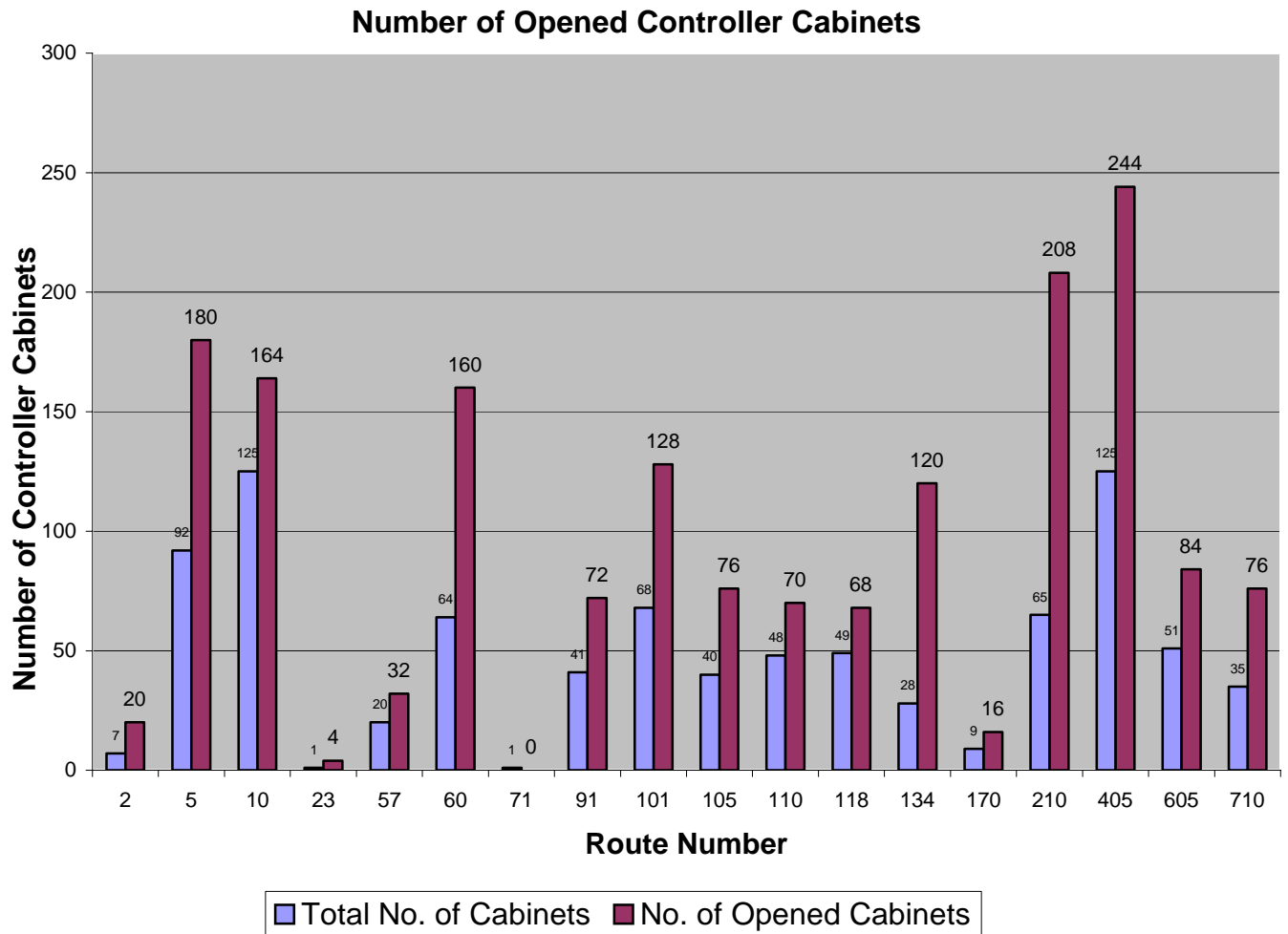
1. Surveillance and Monitoring of Ramp Operation

Currently, District 07 has around 870 metered on ramps and 19 freeway to freeway connectors, making it the largest ramp metering District in California. Ramp Metering personals periodically perform field surveillance and correct minor software and hardware problems associated with the metering operation. They observe traffic backup on the ramp, verify appropriate metering rate and check for any malfunction with signal lights or advance warning signs. If the meter is off during metering hours, the controller software program and cabinet hardware will be checked in order to diagnose the problem; minor issues will be corrected, while major problems are reported to Electrical maintenance or ITS Branch for repairs.

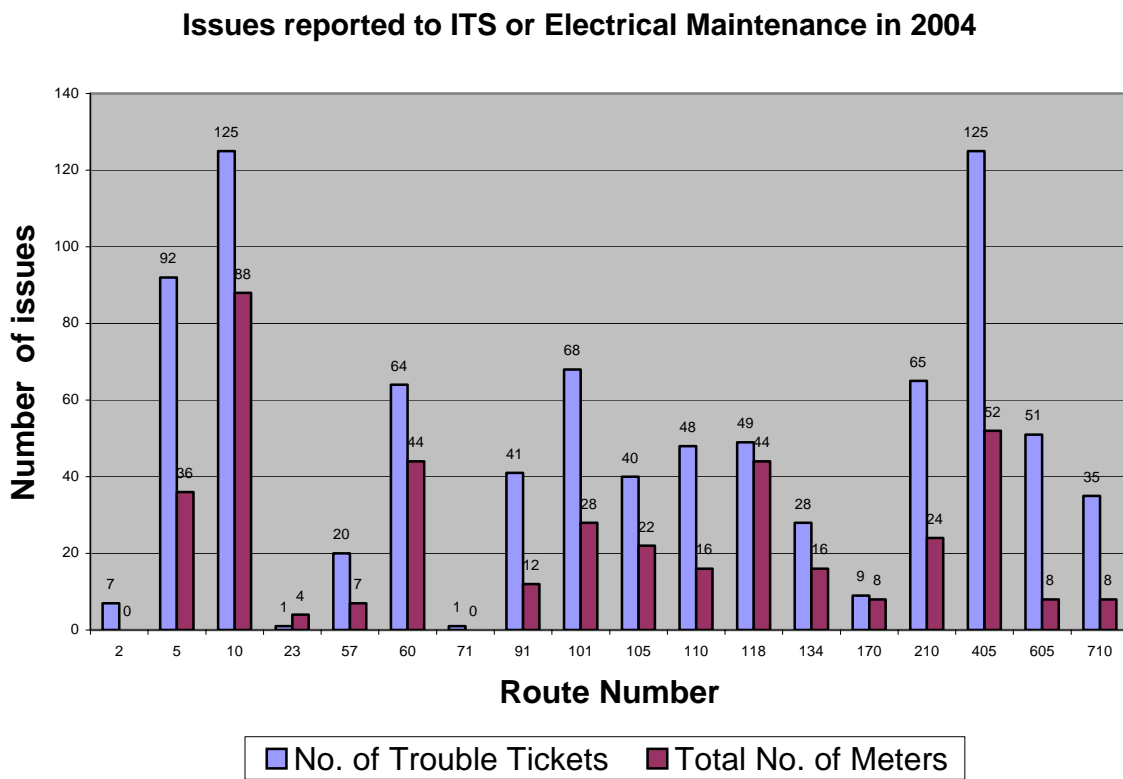
During the course of 2002, Ramp Metering unit opened and checked the District's ramp-meter controllers over 2,800 times. The reasons for checking these controller cabinets varied from simply verifying the operation of the ramp meter to performing corrections or update to the programmed software and in some cases resetting or replacing minor cabinet hardware. The high number for opened controllers in 2002 was largely due to data gathering in order to prepare on-ramp data summaries covering all metered ramps in the district. These summaries were used to initiate hardware revisions and update programmed software needed prior to the installation of SATMS 3.0 District wide. As a result of this effort, over 500 RAM pages were revised and around 200 ATMS modifications were made.

In 2003, following the installation of the SATMS 3.0, ramp metering performance was enhanced leading to a reduction in both software and hardware problems. Thus, the numbers of opened controller cabinets went down to an estimated 2000 controllers. Furthermore, this number was reduced to 1722 in 2004. In addition, approximately 140 RAM pages were modified in 2003 and close to 75 in 2004. The following chart indicates

the number of times that a controller cabinet was opened on various routes within the District.



In instances when a ramp meter problem could not be fixed by Ramp Metering personnel, the issue would be reported to either ITS branch or Electrical Maintenance for repairs. In 2002, 862 ramp metering problems were reported. However, the number dropped to 409 in 2004. The following chart indicates ramp metering issues reported throughout various routes in the district.



2. RAMP METER COUNTS

There are two types of traffic counts conducted by the Ramp Metering Group:

- A. Queue and demand count
- B. HOV Occupancy count.

"Queue and Demand" counts are intended to study the operation of the on-ramp including time and extent of the traffic backup (Queue) due to the ramp metering application. Another main purpose for this count, besides measuring the peak vehicular demand at the ramp, is to distinguish the number and, in some cases time intervals, when large vehicles (Trucks, Buses, Trailers...) are using the on-ramp. Noting this various information helps to implement effective ramp metering strategy, as metering rates are implemented according to type and volume of traffic demand at the on-ramp, in relation to mainline traffic condition.

"HOV Occupancy" counts are conducted at on-ramps equipped with an HOV by-pass lane (Carpool lane). The purpose of these counts is to determine time intervals, type of vehicles (2 persons, 3 + persons, buses, motorcycles) and percentage of usage on the HOV lane in relation to the metered mix flow lane. In addition, the number of violation to the HOV (minimum 2 persons) policy is recorded; if the violation rate is determined to be high, the information will be passed along to the California Highway Patrol for enforcement.

These two types of counts should be conducted, on yearly basis, at all active ramp meter locations. However, due to time constraints and limited resource allocations, these counts are currently performed as needed, usually as a result of public complaints or upcoming projects or developments impacting the operation of the ramp meter. Thus, if a public complaint related to excessive back up on the ramp is received, a "Queue and Demand" count might be conducted to properly investigate the problem and adjust the metering rate accordingly. In addition, if a project to construct a new ramp or modify an existing one is being proposed, then a traffic count will be needed, in order to assist in the new design. On-ramp Counts might also be conducted during major studies (Swarm testing), or large scale projects (Route 5 HOV widening and HOV project).

During the 2002 calendar year, Ramp Metering unit conducted 63 "Queue and Demand" and 21 "HOV Occupancy" counts. However, in 2004 due to funding constraints, the numbers were reduced to 27 and 15 for "Queue and Demand" and "HOV Occupancy" counts respectively.

3. Capital Project Review

Ramp Metering group reviews numerous projects and gets involved in ramp meter related issues, during the following stages:

1. PID (Project Initiation Document)
2. PSR (Project Study Report)
3. PR (Project Report)
4. All stages of PS&E (Plan Specifications and Estimate)

In addition, Ramp Metering engineers follow up on the progression of these projects during the construction stage.

4. IGR / Permit project Review

Ramp Metering Engineers review and comment on ramp meter related issues involved in permit projects, Inter Governmental Review (IGR) reports and Oversight projects, usually prepared by consultants on behalf of local Cities, Counties or agencies.

5. Metered Ramp Data Summary

In the spring of 2002, ramp metering personnel were involved in gathering information for the METERED RAMP DATA SUMMARY. Information gathered included but are not limited to the following items:

- Ramp type and configuration
- Number of lanes
- Ramp storage
- “Meter On” signs
- HOV and pullout locations
- Metering hours
- Metering rates
- Inventory of loops
- Signing
- Striping

This information was gathered for the following reasons:

- Provide a database for the “RAMP METER DEVELOPMENT PLAN” report.
- Generate a master list detailing all deficiencies and forward it to ITS group for repairs.
- Replace on-ramp traffic loops, detector cards and reconfigure detector loop connection (DLC), when needed, at numerous traffic controller cabinets, in preparation of the SATMS 3.0 installation.

6. Ramp Meter Development Plan (RMDP)

The last 10-year RMDP report was completed in 1997 and was due to be updated by 2007. Thus, an updated RMDP report was initiated in 2004 and published in July of 2005. This 10-year report contained an inventory of all on-ramps (metered and non-metered), metered connectors, in addition to a listing of on-ramps proposed or funded to be metered within the next 10 years. For detailed information, please refer to REFERENCES, Item No. 2.

7. Ramp Metering Field Procedure Manual

In November 2002, Ramp Metering unit completed and published a “RAMP METERING FIELD PROCEDURE MANUAL”. This manual was prepared as a guide for useful field procedures. It is referred by Ramp Metering, ITS and Electrical Maintenance personals, when troubleshooting various ramp metering problems. An amendment to this manual was completed in June 2005, indicating updates to some field procedures, following the installation of the SATMS 3.0. For detailed information, please refer to REFERENCES, Item No. 3.

REFERENCES

1. “Ramp Meter Design Guidelines”, Caltrans, January 2000.
2. “Ramp Meter Development Plan”, Wahib Jreij & Mohamed Iqbal Toorawa, April 2004.
3. Amended “Ramp Metering Field Procedure Manual”, Rafael Benitez-Lopez, November 2005.
4. “Preliminary SWARM Study Report”, Hanh Pham, November 2001.
5. “SWARM Study Final Report”, Hanh Pham, October 2002.
6. “ATMS User’s Manual”, National Engineering Technology Corporation, June 2000.
7. “ATMS Traffic Engineer’s Manual”, National Engineering Technology Corporation, June 2000.
8. “Highway Capacity Manual”, Transportation Research Board, 2000.
9. “Traffic Manual”, Caltrans
10. “Highway Design Manual”, Caltrans
11. “Twin Cities Ramp Meter Evaluation”, Cambridge Systematics Inc., November 27 2001.
12. “Traffic Bulletin No. 4 - Notes on Freeway Capacity”, Karl Moskowitz and Leonard Newman, July 1962.
13. “Traffic Bulletin No. 16 – Introduction to Capacity”, Leonard Newman, April 1969.
14. “Ramp Meter Operation Plan”, National Engineering Technology Corporation, December 2001.
15. “Basic Ramp Control”, M.K. Kim, Caltrans
16. Route 405 SWARM Study Summary, Wahib Jreij & Fady Al-Awar, January 2003.

ATTACHMENTS

ROUTE RESPONSIBILITIES

Afsaneh Razavi (Ramp Metering Branch Chief)

Phone (213) 897-0267

AREA ENGINEER: Wahib Jreij

Phone: (213) 897- 8483

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-10	18.39/48.30	Route 101 to San Bernardino C.L.	Jreij / Dumaplin	7-8483
LA-14	24.79/77.01	Route 5 to Kern County Line	Jreij	7-8483
LA-57	0.00/12.00	Orange County Line to Route 210	Jreij / Dumaplin	7-8842
LA-60	0.00/30.50	East LA Inter. to San Bernardino C.L.	Jreij / Akramian	7-8483
LA-71	0.30/4.80	San Bernardino C.L. to Route 10	Jreij / Dumaplin	7-8842

AREA ENGINEER: Iqbal Toorawa

Phone: (213) 897- 9133

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-91	6.01/20.74	Vermont to Orange County Line	Toorawa	7-9133
LA-110	0.00/20.36	Route 47 to Rte 05	Toorawa	7-9133
LA-110	20.36/31.91	Route 05 to end of Freeway	Toorawa	7-9133
LA-110	Connector	(E/W)/B 105 to N/B 110	Benitez	7-1666
LA-110	Connector	E/B 105 to S/B 110	Benitez	7-1666
LA-110	Connector	W/B 105 to S/B 110	Benitez	7-1666
LA-110	Connector	S/B 5 to S/B 110	Toorawa	7-9133
LA-105	0.00/18.14	Airport (LAX) to Studebaker	Benitez	7-1666
LA-105	Connector	N/B 405 to E/B 105	Benitez	7-1666
LA-105	Connector	S/B 405 to E/B 105	Benitez	7-1666
LA-105	Connector	N/B 110 to E/B 105	Benitez	7-1666
LA-105	Connector	S/B 110 to W/B 105	Benitez	7-1666
LA-105	Connector	S/B 110 to E/B 105	Benitez	7-1666
LA-105	Connector	N/B 710 to W/B 105	Benitez	7-1666
LA-105	Connector	N/B 710 to E/B 105	Benitez	7-1666
LA-105	Connector	S/B 710 to E/B 105	Benitez	7-1666
LA-105	Connector	S/B 710 to W/B 105	Benitez	7-1666

AREA ENGINEER: Hanh Pham

Phone: (213) 897- 8772

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-2	14.08/23.44	Glendale Blvd to Route 210	Pham / Dumaplin	7-8842
LA-134	0.0/13.34	Route 170 to Route 210	Pham / Dumaplin	7-8842
LA-210	0.00/52.00	Route 5 to San Bernardino C.L.	Pham / Dumaplin	7-8772
LA-405	0.00/12.95	Orange County Line to Route 110	Atefyekta	7-9292
LA-405	12.95/21.44	Route 110 to Route 105	Torchin	7-6576
LA-405	Connector	E/W 105 to S/B 405	Benitez	7-1666

ROUTE RESPONSIBILITIES

Afsaneh Razavi (Ramp Metering Branch Chief)

Phone (213) 897-0267

AREA ENGINEER: Hamid Kalkatechi

Phone: (213) 897- 0294

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-5	26.65/88.61	Rte 134 to Kern County Line	Kalkatechi	7-0294
Ven-33	0.00/5.66	Route 101 to Casitas Vista Road	Kalkatechi	7-0294
LA-101	11.60/38.19	Rte 101/134/170 Int. to Ventura C.L.	Kalkatechi / Atef.	7-0294
Ven-101	0.00/43.62	LA County Line to Santa Barbara C.L.	Kalkatechi	7-0294
Ven-126	0.00/13.24	Route 101 to LA County Line	Kalkatechi	7-0294
Ven-126	0.00/13.24	Route 101 to Hallock Drive	Kalkatechi	7-0294
LA-138	0.00/1.80	Route 5 to Gorman Post	Kalkatechi	7-0294
LA-170	14.57/20.55	Route 101 to Route 5	Kalkatechi	7-0294
LA-10	1.88/18.33	4th Street to East LA Interchange	Benitez	7-1666

AREA ENGINEER: Jack Kao

Phone: (213) 897- 9183

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-5	0.00/26.65	Orange County Line to Rte 134	Kao / Nguyen	7-9183
LA-605	9.61/26.00	Route 05 to Route 210	Masatsugu	7-6372
LA-605	0.00/9.61	Orange County Line to Route 05	Nguyen	7-2074
LA-605	Connector	E/B 105 to N/B 605	Benitez	7-1666
LA-605	Connector	E/B 105 to S/B 605	Benitez	7-1666
LA-710	6.80/32.70	Route 1 to Route 210	Kao	7-9183
LA-710	Connector	E/W 105 to S/B 710	Benitez	7-1666
LA-710	Connector	E/W 105 to N/B 710	Benitez	7-1666

AREA ENGINEER: Fady Al-Awar

Phone: (213) 897- 2083

Co/Rte	PM Limits	Limits	Assigned	Ph. Ext
LA-101	0.18/11.60	Mission Rd to 101/134/170 Int.	Al-Awar	7-9292
LA-118	0.00/14.08	Ventura County Line to Route 210	Al-Awar	7-2083
Ven-118	18.20/32.60	Route 23 to LA County Line	Al-Awar	7-2083
Ven-23	3.20/11.60	Route 101 to Route 118	Al-Awar	7-2083
LA-405	48.64/39.40	Route 05 to Route 101	Al-Awar	7-2083
LA-405	39.40/21.44	Route 101 to Route 105	Torchin	7-6576
LA-405	Connector	W/B 105 to N/B 405	Benitez	7-1666
LA-90	0.92/3.28	Route 1 to Slauson	Torchin	7-6576

California Department of Transportation
DEPUTY DIRECTIVE

Number: DD-35

Refer to
Director's Policy: 08-Freeway System
Management

Effective Date: 1-3-95

Supersedes: P&P 91-01

Title: Ramp Metering

POLICY

Caltrans is committed to using ramp metering as an effective traffic management strategy to maintain an efficient freeway system and protect the investment made in constructing freeways to keeping them operating at or near capacity flow rates.

DEFINITION/BACKGROUND

Ramp metering is the common method of ramp entry control. It has been an effective tool in reducing congestion on California freeways since the late 1960s. Caltrans has installed over 1300 ramp meters throughout the state and proposes their installation on all urban freeway entrance ramps where metering will improve or maintain effective operations along freeway corridors.

RESPONSIBILITIES

The Traffic Operations Program Manager is responsible for the development, review and dissemination of policies, guidelines, and procedures for ramp metering (see Ramp Metering Policy Procedures).

The State and Local Project Development Program Manager is responsible for the development and review of geometric design standards for ramp metering and supports the inclusion of ramp metering in projects within freeway segments identified in the Ramp Meter Development Plan.

District Directors are responsible for developing local agency support for ramp metering; implementing ramp metering policies and procedures; and providing justification for deviation from established policy and procedures.

APPLICABILITY

Any employees involved with ramp metering activities.

ORIGINAL SIGNED BY

LEE F. DETER

Deputy Director

Maintenance and Operations

Attachment 2

RAMP METERING POLICY PROCEDURES

State of California
Business, Housing and Transportation Agency
Department of Transportation
Traffic Operations
August 1997

Attachment 3

RAMP METERING POLICY PROCEDURES

I. PURPOSE

The purpose of these procedures is to provide guidelines for implementing the Department's ramp metering policy (DD-35).

II. BACKGROUND

Metering has proven to be an effective traffic operations tool to maximize the efficiency of a corridor. The primary objective of metering is to reduce congestion and the overall travel time of the total traffic stream - on both freeway and surface streets. Ramp metering reduces congestion by:

- Maintaining more consistent freeway throughput.
- Utilizing the capacity of the freeway corridor more efficiently.
- Providing incentives for increased use of carpools, vanpools, and public transit by including preferential lanes, which offer timesavings to High Occupancy Vehicles (HOV) at ramp meters.

Secondary benefits include the reduction of congestion-related accidents and air pollution. Ramp meters operate most effectively when upstream mainline traffic is controlled. This control can be accomplished by installing additional ramp meters, metering freeway to freeway connectors or mainline control. These procedures focus on the implementation of ramp metering systems through a coordinated effort involving Caltrans planners, designers, operations personnel, local agency staff, the California Highway Patrol (CHP), and the public.

III. PROCEDURES

- A. It is the District's responsibility to maintain an acceptable level of service on the freeway system, to make the most effective use of each transportation corridor, and to protect the public's investment in the system.

Each District that currently operates, or expects to operate, ramp meters within the next ten years shall prepare a Ramp Meter Development Plan (RMDP) identifying the freeway segments, including freeway to freeway connectors, that are expected to be metered within this period. The RMDP should also identify freeway segments where upstream mainline control is necessary to maintain effective overall freeway operations. The RMDP shall be updated biennially and be included in local Congestion Management Plans.

- B. Projects, which propose the modification of an existing interchange or the construction of a new interchange within the freeway segments identified in the RMDP, regardless of funding source, should include provisions for ramp meters. This applies to all projects that have an approved Project Study Report dated July 1991 or later (the date of the original Policy and Procedure). These provisions, as defined in the Ramp Meter Design Guidelines, should include right of way, geometric to accommodate vehicle storage and HOV bypass lanes, ramp meter equipment, and CHP enforcement areas. Projects which propose additional capacity within freeway segments identified in the RMDP shall include provisions for ramp meters and shall implement the ramp meters at all entrance ramps within the project limits. In freeway segments identified in the RMDP where mainline control is necessary to maintain effective overall freeway operation, additional freeway capacity should not be constructed without an analysis of the operational impacts to downstream segments. Districts are responsible for performing appropriate environmental studies for ramp metering projects.
- C. The District will work in partnership with metropolitan planning organizations; regional transportation planning agencies, and congestion management agencies to program ramp metering projects and develop implementation plans. Coordination and consultation should be documented and concurrence may be obtained in any form the District considers appropriate.
- D. The Ramp Meter Design Guidelines prepared by the Division of Traffic Operations, in cooperation with the Division of State and Local Project Development, and the CHP shall be used when designing ramp metering facilities. This document is a compilation of design information and operational practices used statewide.
- E. HOV preferential lanes shall be considered wherever ramp meters are installed. The need for HOV bypass lanes should be included in the Project Study Report, Project Information Report, Project Report, and Environmental Document. If an HOV preferential lane is not included in a proposal to ramp meter, the reasons should be addressed in the appropriate document.

The District is responsible for consulting with the CHP on project features, which affect enforcement activities such as HOV lane violations, enforcement pads, etc. Coordination and consultation should be documented.

- F. When selecting the appropriate metering method for the HOV preferential lane, the following criteria should be used:

Control: An analysis of HOV traffic volumes shall be made to determine the impact on mainline traffic flows. Where adverse impacts exist, consideration should include metering the HOV preferential lane and/or more restrictive metering of the SOV lane(s). Consideration should be given to metering the HOV preferential lane if platoons from local signalized intersections adversely affect the operation of the freeway. Storage capacity and effects to local arterials should also be addressed.

Merge Conditions: Prior to entering the freeway, all vehicles on the on-ramp should be provided with adequate space to safely merge with each other. The safest merge condition is when the speeds of the merging vehicles are identical. When the speed differentials between HOVs and SOVs are excessive, consideration should be given to metering the HOV lane. All ramps should be designed in accordance with the Ramp Meter Design Guidelines, which detail adequate merging distances.

Enforcement: The ability to safely enforce occupancy violations of HOV lanes is essential. The CHP should be consulted for their recommendation of enforcement operations at each HOV preferential lane location.

Corridor Operations: In corridors where ramp meters are already operational, the existing metering method may be used as criteria for additional installations in the same corridor. Should alternate metering methods be proposed along a corridor, local agencies should be consulted.

The criteria listed above can be applied to new and existing ramp meter installations. If it is being applied to an existing ramp meter, the following criteria should also be used:

Accident History: The accident history of the ramp needs to be investigated. If either the ramp or any portion of the freeway within 500 feet of the ramp gore has been flagged as a high accident concentration location (Table C), each accident report should be reviewed in detail to determine whether or not the HOV operation during the metered period was a contributing factor. If evidence suggests that it could have been a contributing factor to the accident, consideration should be given to metering the HOV preferential lane.

- G. Districts shall provide justification for deviation from the policy and these procedures and concurrence shall be obtained from the Headquarters Traffic Operations District Liaison. Deviations from design standards require the approval of the Project Development Coordinator in the Office of Project Planning and Design.
- H. The Division of Traffic Operations provides District personnel with technical assistance and support on the design and operation of ramp meter systems and assists in the preparation of the District's RMDP.

CONTENTS OF EXCEPTION TO RAMP METERING POLICY FACT SHEET

PROJECT DESCRIPTION

Briefly describe the project. Note the type of project and/or major elements of work to be done.

RAMP METERING POLICY NON-COMPLIANCE FEATURES

Describe the proposed or existing ramp metering policy non-compliance feature(s). (Note: Deviations from advisory or mandatory design standards shall be addressed as required by the *Project Development Procedures Manual*, the *Highway Design Manual* and applicable District Directives.) Design exceptions to standards to be attached to Ramp Meter Policy Fact Sheet.

REASON FOR THE EXCEPTION

Be thorough but brief. Supportive factors may include right-of-way or space constraints, environmental concerns, inordinate costs, etc. Show an estimate of the added cost above the proposed project cost that would be required to conform to the ramp metering policy for which exception is being documented. The estimate does not have to be highly developed but must be realistic.

FUTURE CONSTRUCTION

Describe any planned future projects in the immediate vicinity of the requested ramp meter exception, but do not make any commitments (e.g., ramp metering as part of future projects) unless there is a certainty that they can be followed through.

PROPOSED EXCEPTION REVIEWS AND CONCURRENCE

Note reviews by HQ Traffic Operations, the District Liaison and District Office of Traffic Systems. Give dates of reviews and discuss any comments that were made and their disposition.

REMARKS

Note clarifying remarks. Discuss impacts on project delivery schedule and project costs, if any. Discuss impacts of ramp metering policy non-compliance features.

ATTACHMENTS

Provide a locations map and/or vicinity map for the project, indicating the location of the requested exception(s) to the ramp metering policy. Also provide cross-sections and/or special details as necessary to illustrate the policy non-compliance condition. Letters, resolutions, traffic studies, etc., which help to clarify the reasons for the exception request, may be attached.

SIGNATURE SHEET

The Fact Sheet signature page shall conform to the attached.

Dist-Co-Rte-KP
Source Unit – EA
Project Cost

FACT SHEET

EXCEPTION TO
RAMP METERING POLICY

(Insert Registered C.E. Seal)

Prepared by:

(Name), Registered C.E.

Date

Telephone

Approval recommended by:

(Name), Project Manager

Date

Telephone

Concurrence by:

(Name), District Liaison
HQ Traffic Operations

Date

Telephone

Approved by:

(Name), District Division Chief,
Operations

Date

Memorandum

To: DISTRICT DIVISION CHIEFS – Operations **Date:** July 31, 2000
DISTRICT DIVISION CHIEFS – Design
DISTRICT DIVISION CHIEFS – Planning **File:**

From: DEPARTMENT OF TRANSPORTATION
Traffic Operations
Mail Station 36

Subject: Ramp Metering Policy on High Occupancy Vehicle (HOV) Preferential Lanes

The purpose of this memorandum is to clarify and re-affirm the California Department of Transportation (Caltrans) policy on HOV preferential lanes at ramp meter locations. Caltrans is committed to its current policy: **An HOV preferential lane shall be provided at all ramp meter locations.**

The January 2000 edition of the Ramp Meter Design Manual now addresses the circumstances under which exceptions to this policy may be warranted. See 'Modifications to Existing HOV Preferential Lanes' located in Section 'I' of Chapter One:

- Underutilization of an existing lane plus the need for additional right-of-way for storage
- The availability of an alternate HOV entrance ramp within 2 Km
- The availability of a direct HOV access (drop) ramp

Exceptions shall be handled on a location-by-location basis. Conversions may require Federal Highway Administration actions or concurrence. The District Division Chief for Operations, in consultation with the Headquarters Traffic Operations Liaison, is responsible for approving and documenting decisions to remove HOV preferential lanes. These policies and exceptions also apply to new and reconstruction projects. Districts should refer to the "Exception to Ramp Metering Policy" located in the Appendix of the Ramp Meter Design Manual or contact your Headquarters Traffic Operations Liaison for assistance.

Original Signed By

KIM NYSTROM
Program Manager
Traffic Operations

cc: Mr. Robert Buckley
Program Manager
Design and Local Programs

Ms. Joan Sollenberger
Program Manager
Transportation Planning